

Real Time Audio Signal Processing Through AM Using Simulink

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Abstract

This research work explicates the various simulation results using Simulink and System Generator. Initially the most important analog modulation technique which is AM modulation technique is elucidated. Afterwards this modulation technique is constructed and tested with in Simulink. Prior to realization of this design within System Generator the audio signal is imported to the Simulink and the simulation results are investigated.

Keywords: Simulink, System Generator, analog modulation, AM modulation.

INTRODUCTION

Communication system can transmit and receive analog or digital signals. Analog modulation can be characterized as Amplitude Modulation (AM), Frequency Modulation (FM), or Phase Modulation (PM). In these modulations the information or baseband signal will be attached to corresponding properties of carrier signal, for example in AM modulation the information is attached to the carrier amplitude. This section covers two modulation schemes. These modulations are AM and DSB-SC modulations. First, AM modulation is discussed then looked into DSB-SC modulation.

AM MODULATION

In order to analyze AM modulation first a message $m(t)$ and a carrier wave $c(t)$ are defined. These waves are illustrated in Equation 1. In this equation, A_m is message signal amplitude, A_c is carrier signal amplitude, f_m is message signal frequency, and f_c is carrier signal frequency.

$$m(t) = A_m \cos(2\pi f_m t), \quad \dots\dots (1)$$

$$c(t) = A_c \cos(2\pi f_c t)$$

Now the AM modulated wave $s(t)$ is defined by

$$s(t) = A_c [1 + k_a m(t)] \cos(2\pi f_c t) \quad \dots\dots (2)$$

In equation 2 the k_a is called the amplitude sensitivity. In order to detect envelope of

modulated wave $s(t)$ properly and avoid envelope distortion the amplitude of $k_a m(t)$ should be less than one. Demodulation of the AM modulated wave is done by envelope detection method. This method of the demodulation recovers the baseband signal by removing half of the envelope, and after this process uses a low-pass filter to remove high frequency components of the recovered signal. AM modulation was one the first modulations that was developed but it is still used in standard AM frequency spectrum from 535 to 1605 kHz [1]. Next, the AM modulation and demodulation is constructed and analyzed.

DSB-SC MODULATION

Next, the characteristic of the Double SideBand-Suppressed Carrier (DSB-SC) modulation is discussed. The DSB-SC has an advantage of simple modulation which is multiplying the message signal and carrier signal directly. However, it required a much more complex demodulator circuit. In addition, this modulation reaches to zero when the message signal is turned off [2]. In this section only coherent detection or synchronous demodulation method is discussed, which assumed that local oscillator is synchronized with AM modulated signal. This method also can be implemented on FPGAs since both modulator and demodulator partitions use

the same clock.

SIMULATION WITHIN MATLAB / SIMULINK

AM modulation can be implemented in

several different ways within Simulink; two of these methods are demonstrated in Figure 1. The first method uses the DSB AM modulator blocks from Communication Blockset of Simulink

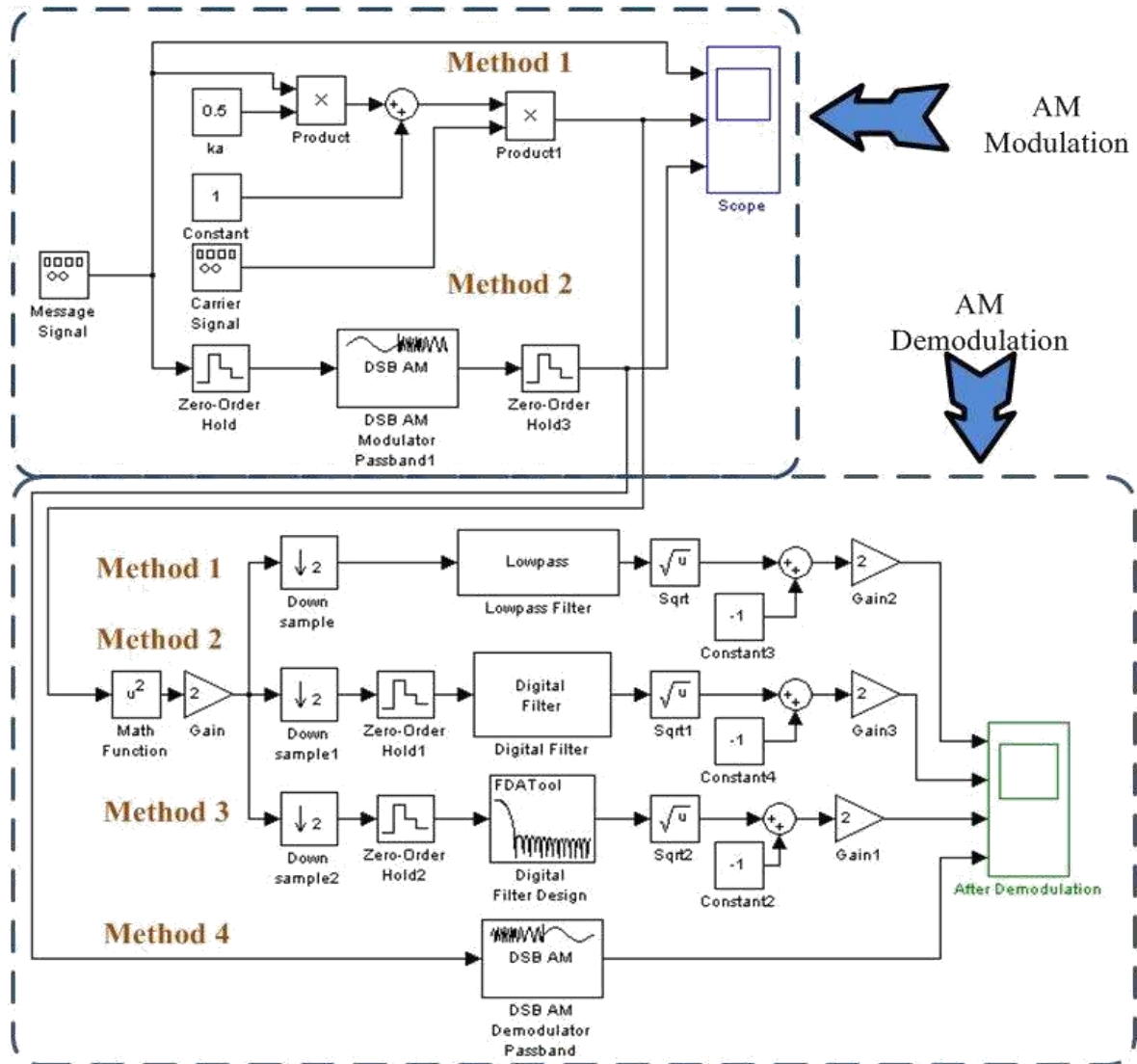


Fig 1. AM Modulation and Demodulation within Simulink

The other method leverages the use of product block to mix the message signal $m(t)$ with carrier signal $c(t)$. First, the envelope detector method simulated within Simulink which is shown in the lower section of Figure 7. Again, there are several methods that can be used to implement the envelope detection process. One of these methods is called DSB AM demodulator which is marked as Method 4 in this figure. The other methods are implemented by

squaring the modulated signal and low-pass filtering [3] which is illustrated in Method 1s through 3. Among these modulation and demodulation methods, the Method 1 AM modulation and Method 3 AM demodulation methods can be transferred into System Generator and later implemented on an FPGA since currently the similar blocks are exist in System Generator library.

Simulation results from Simulink are shown in Figure 2 and Figure 3. In Figure 3 the input sine signal is shown on the top,

the modulation Method 1 is illustrated in the middle, and the modulation Method is shown on the bottom.

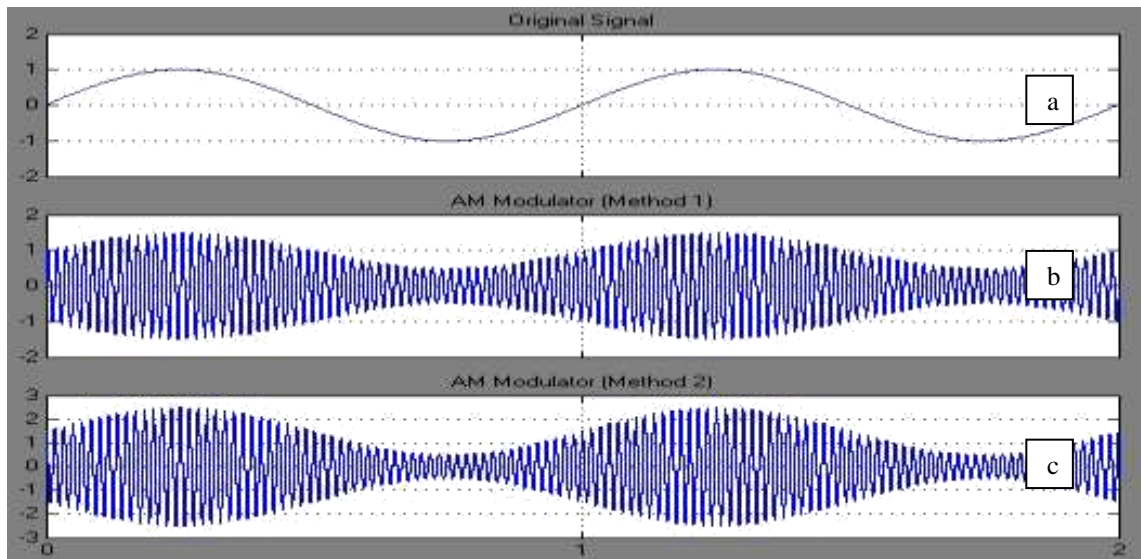


Fig 2. Simulation Results of AM Modulation in Simulink (a) Input Sine Signal (b) Method 1 Modulation (c) Method 2 Modulation

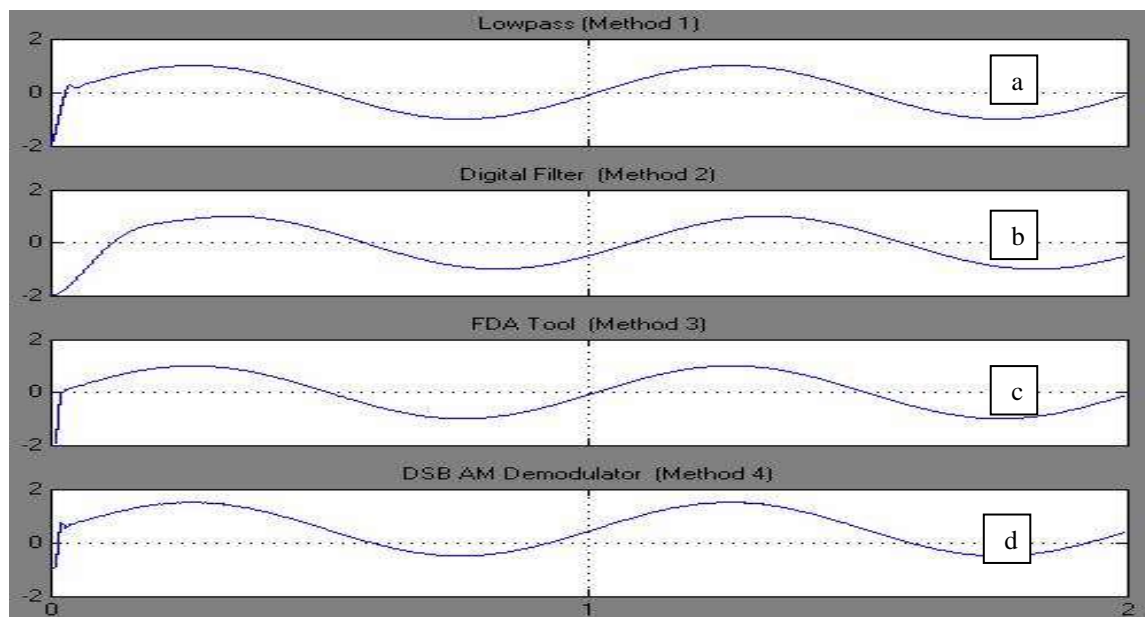


Fig 3. Simulation Results of AM Modulation in Simulink (a) Method 1 Demodulation (b) Method 2 Demodulation (c) Method 3 Demodulation (d) Method 1 Demodulation

The input audio file is mono format with sample rate of 22.05 kHz. Figure 10 illustrates the AM modulation and demodulation of this sample audio signal in Simulink.

with original audio signal by observing them on a scope and spectrum scope tools within Simulink [4]. The results show the recovery of original signal after demodulation process.

The demodulated audio signal compared

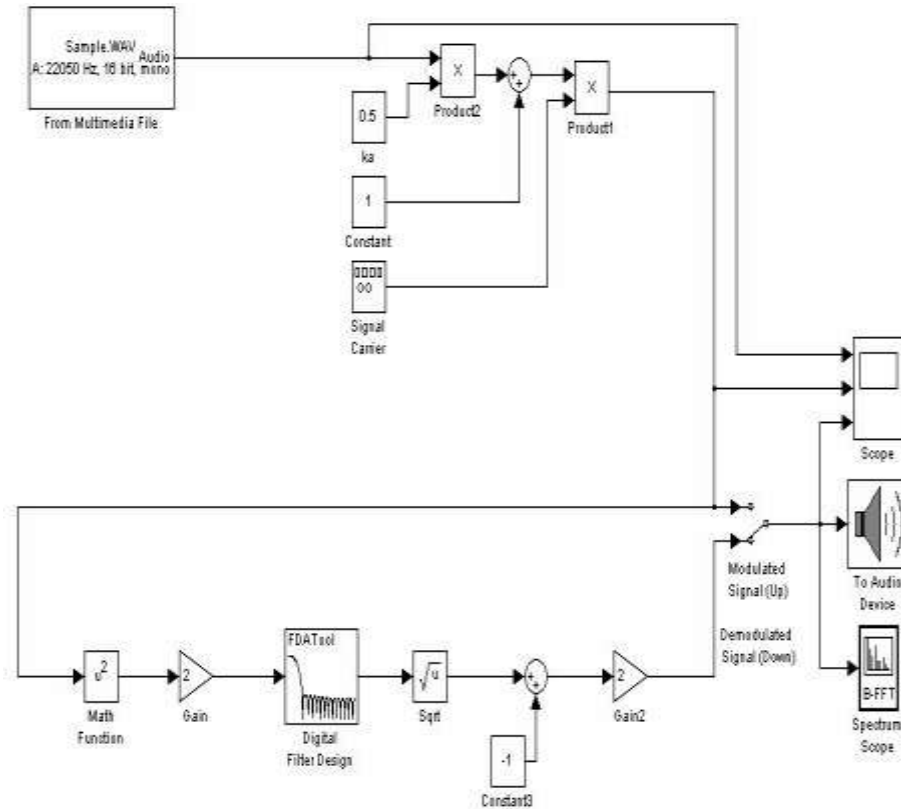


Fig 4. AM Modulation and Demodulation of an Audio Signal in Simulink

Figure 5 shows the comparison of a portion of this sample audio signal with its demodulated signal in a time domain. This figure also illustrates the spectrum of

modulated signal. Figure 6 illustrates the frequency spectrum of this sample audio signal and its modulated signal.

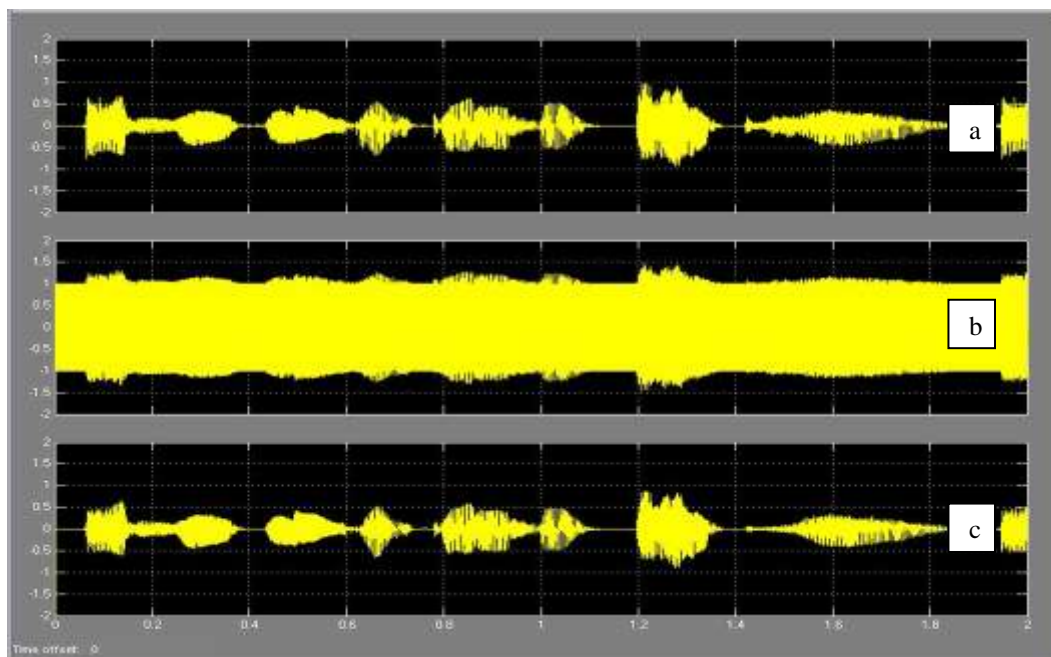


Fig 5. Simulation Results of AM Modulation of an Audio Signal in Simulink (a) Input Audio Signal (b) Audio Signal after Modulation (c) Recovered Audio Signal after Demodulation

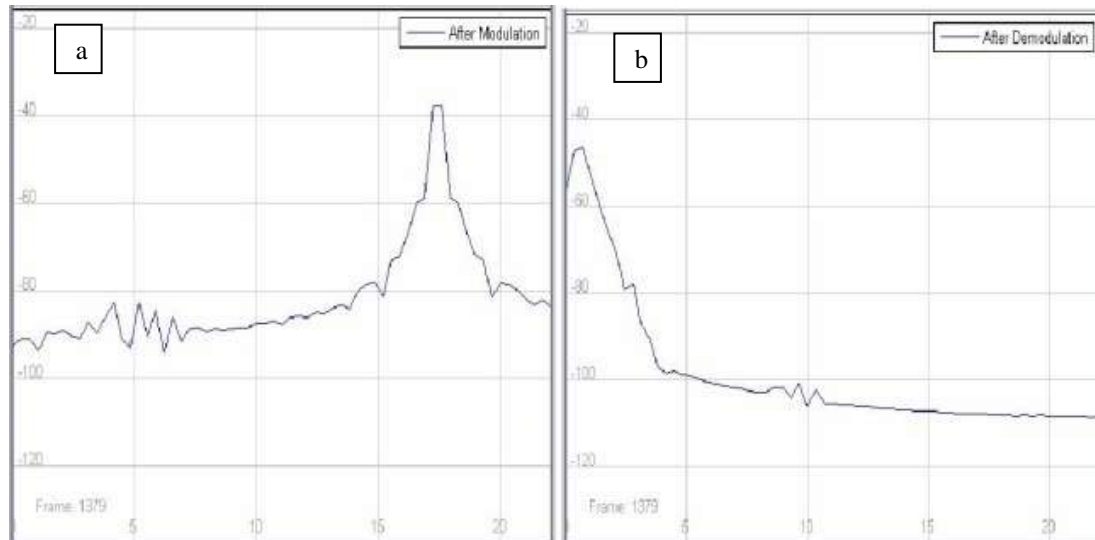


Fig 6. Frequency Spectrum of an Audio Signal after Modulation (a) and Demodulation (b) for AM Modulation

CONCLUSION

Using Simulink and System Generator this work has been explicated the various simulation results. Initially, AM modulation technique was elucidated which is the most important analog modulation technique. Within Simulink this modulation technique was constructed and tested. Within System Generator the simulation results are investigated.

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